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MANAGING MICRONUTRIENTS IN THE GREENHOUSE

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MICRONUTRIENT EXCESS

Excesses Can Cause Deficiencies. Excessive application of micronutrients probably accounts for more micronutrient disorders in the greenhouse than does insufficient application. Excessive application of micronutrients, in addition to toxicities, can lead to micronutrient deficiencies. Deficiencies in this case are due to antagonisms between micronutrients during plant uptake. When two nutrients are antagonistic, a super-optimal concentration of one in the root medium will suppress plant uptake of the other.

High root medium levels of iron commonly cause manganese deficiency and to a lesser extent can suppress zinc uptake (Table 1). Conversely, high root medium levels of manganese cause iron deficiency and also to a lesser extent, zinc deficiency. High levels of copper cause zinc deficiency and conversely, high levels of zinc cause copper deficiency. Thus, it is possible to encounter deficiencies of iron, manganese, copper or zinc as a result of excess application of other micronutrients. These deficiencies can occur even when a normally sufficient concentration of the deficient micronutrient exists in the root medium.

Table 1. Common micronutrient antagonisms.

High soil level of:	Results in low plant level of:
iron	manganese, zinc
manganese	iron, zinc
copper	zinc
zinc	copper

What Causes Excesses? Many combinations of micronutrients are used in greenhouses. Each can be safe and effective when used in the role for which it was formulated. Excesses usually occur when multiple combinations of micronutrients are applied. This occasionally happens because some of the micronutrient sources are not obvious to the grower. Following are five sources or factors which provide or make micronutrients available.

❶ Most root media, whether commercially or self prepared, contain micronutrients.

❷ Most commercially formulated greenhouse fertilizers contain micronutrients. Fertilizers prepared by the greenhouse firm as an alternative to commercial products are often formulated with micronutrients. Generally, plants respond well to the combination of micronutrients in root media and fertilizers.

❸ Specific fertilizers are commercially available for use in soilless media that have higher micronutrient concentrations than the standard greenhouse fertilizers. The differences in micronutrient content between the standard and the soilless media formulations of one given fertilizer analysis are given in Table 2. The increase of micronutrients in the soilless media formulation ranges from 200 percent for iron to 1,000 percent for molybdenum. This third source of micronutrients can be justified in a soilless root medium where the pH level is 6.0 or higher because the availability of micronutrients is strongly reduced in this situation.

❹ Research has indicated that, as is the case for organic field soils, the optimum pH level for organic (soilless) greenhouse root media can be one pH unit lower than that desired for soil based root media (Peterson, 1982). The optimum pH range for soil-based media is 6.2 to 6.8 while for soilless media it is 5.5 to 6.0. When the pH level decreases, the availability of all micronutrients except molybdenum increases. Molybdenum availability decreases; however, deficiency of this nutrient is not known to be a problem in any floral crop except poinsettia. Thus, growing at a lower pH level is equivalent to making an addition of micronutrients to the plant. Growers who maintain a pH level below 6.0 should consider using the standard fertilizer formulations.

❺ Often the four causes of increased micronutrient availability just discussed lead to excess availability. Excess presence of one or more members of the micronutrient group can block uptake of another, bringing about a deficiency of the latter. It is then easy to diagnose the total problem as a micronutrient deficiency. Without further information, correction is usually sought by applying a compete mixture of micronutrients. This makes the situation worse because the causal nutrients which are in excess become even higher in concentration. Even though the deficient nutrient is increased in the root medium, its uptake is not effectively increased.

Table 2. The content of individual micronutrients in a general and a soilless media commercial formulation of 20-10-20 and the micronutrient concentration increase in the soilless media formulation.

	Content (%)		
Nutrient	Standard	Soilless	Increase (%)
iron	0.25	0.50	200
manganese	0.125	0.28	220
zinc	0.013	0.081	620
copper	0.018	0.05	280
boron	0.034	0.10	290
molybdenum	0.005	0.05	1000

Toxicity Correction. It is seldom possible to totally correct micronutrient toxicities. Vigilance should be exercised for preventing them. When toxicity does occur there are three steps which can be taken to reduce the problem.

❶ The first and most obvious step is to stop application of micronutrients. Some fertilizer companies offer fertilizers without micronutrients. Otherwise, one can formulate their own fertilizer without micronutrients.

❷ The second step is to raise the pH of the root medium. The availability of all micronutrients except molybdenum decreases as the pH rises. Iron availability decreases ten-fold when the pH level is raised one unit. Extreme shifts should be avoided. It is sufficient to move the pH level to the upper end of the acceptable pH range for the crop.

Three methods can be used for raising root media pH. **(a).** A shift in the fertilization program from ammoniacal nitrogen (urea, ammonium nitrate, ammonium sulfate) to nitrate nitrogen (potassium nitrate, calcium nitrate) sources will bring about a gradual rise in pH. **(b).** Limestone may be applied to the root medium surface at a rate of approximately 1 lb/cu yd per 0.1 unit rise in pH desired. This rate is for soilless media. Lower rates may suffice for soil-based media. Limestone reacts very slowly, thus two to six weeks may be required for a response. **(c).** For a rapid rise in pH, hydrated lime has been used. Caution should be taken to avoid contact with green tissues and neither limestone nor hydrated lime should be applied directly to ammonium containing fertilizers such as MagAmp or Osmocote. The high pH caused by these liming materials at the surfaces of such fertilizers can convert ammoniacal nitrogen to ammonia gas which is highly injurious to roots and foliage. One pound of hydrated lime should be suspended in 5 gallons of water and then applied to the root medium at the rate of one pint per sq. ft (Koths et al., 1980). This is one quarter the volume normally used for watering.

❸ The third measure which might be taken for alleviating a micronutrient toxicity involves manipulation of antagonistic pairs of nutrients. If the micronutrient present in excess is a member of an antagonistic pair (Table 1) make an application of the other member of the pair. For example, an excess of manganese, in addition to causing manganese toxicity, can result in iron deficiency. Application of iron alone will suppress manganese uptake and will increase iron uptake, thus alleviating both problems.

Diagnosing Micronutrient Status. It is important to diagnose the status of all micronutrients before undertaking corrective measures. As discussed, micronutrient disorders can involve one or more nutrients as well as combinations of toxicities and deficiencies. The presence of one micronutrient deficiency does not indicate that all other micronutrients are low. Application of a complete package of micronutrients in a situation where a deficiency/toxicity situation exists will increase the problem.

There are three systems for diagnosing nutrient status. The best diagnostic tool for micronutrients is foliar analysis. Visual observation of symptoms works but requires that damage be present. Not all damage is reversible. Commercial soil tests do not generally identify levels of all micronutrients. On the other hand, accurate tests and standards have been established for foliar analysis of all micronutrients. While the minimum and maximum critical foliar levels for micronutrients can vary for a few crops, these values do tend to be fairly standard for most crops. The general critical foliar levels for floral crops are presented in Table 3. *(We are very fortunate in North Carolina to have an excellent plant analysis facility managed by NCDA. I encourage all of you to take advantage of their services and expertise whenever you have any problems where nutrition is suspected as a possible cause. Plant analysis is only $4.00 a sample, a wise investment for crop security. Contact your county agent [see page 15 for a listing of agents] for plant analysis sample sheets and sampling instructions or contact Ray Campbell of the Agronomic Division of NCDA [(919) 733-2656] if you have any questions concerning foliar analysis.)*

MICRONUTRIENT DEFICIENCY

There are three alternative methods of application for micronutrients:

❶ Dilute concentrations may be applied in combination with macronutrients during each fertilizer application throughout the crop cycle. Sources, rates, and the final elemental concentration of each micronutrient are given in Table 4. This table will be helpful for those

Table 3. General minimum and maximum critical foliar levels for floral crops.

Nutrient	Minimum (ppm)*	Maximum (ppm)	Comments on maximum levels
iron	40–50**	---	
manganese	30	500–600	fairly uniform over crops
zinc	20	100–200	highly variable
copper	5	20–100	highly variable
boron	20–25	100–300	highly variable
molybdenum	0.1–0.5	---	

*The minimum critical foliar levels apply for most but not all floral crops.

**A high foliar level of manganese will necessitate a higher minimum critical level of iron. Conversely, a higher foliar level of iron will necessitate a higher minimum critical level of manganese.

Table 4. Sources, rates, and final concentration of the micronutrient for continuous soil application of one or more micronutrients with every liquid fertilization.

Micronutrient Source	Weight of source/100 gal oz	Weight of source/100 gal grams	Final conc. (ppm)
iron sulfate--20% iron OR	0.13	3.7	2.00 Fe
iron chelate (EDTA)--12% iron	0.22	6.2	
manganese sulfate--28% manganese	0.012	0.34	0.25 Mn
zinc sulfate--36% zinc	0.0018	0.051	0.05 Zn
copper sulfate--25% copper	0.0027	0.077	0.05 Cu
borax--11% boron OR	0.030	0.85	0.25 B
solubor--20% boron	0.017	0.48	
sodium molybdate--38% molybdenum OR	0.00035	0.010	0.01 Mo
ammonium molybdate--54% molybdenum	0.00025	0.007	

growers who formulate their own fertilizer and want to apply one or more but not all of the micronutrients. When all of the micronutrients are desired most commercially prepared fertilizers can be used since they contain all micronutrients. When fertilizers are self-formulated, commercial products containing all micronutrients can be added into the fertilizer. Some of these products include Peters STEM, Peters Compound 111, and Miller's Mitrel M.

❷ The second method of application calls for higher concentrations to be applied one time as a normal watering. See Table 5 for sources, rates, and final elemental concentrations to be applied in a single application.

❸ The third method involves a single foliar application of micronutrients. Sources, rates, and concentrations for foliar sprays are given in Table 6. Foliar sprays are very useful where root injury due to such factors as disease or poorly drained root medium would reduce root uptake of nutrients. However, the greatest risk of plant injury exists with foliar application. Spraying should be avoided during the mid-day heat. The early morning, after sunrise, is an effective time. Plant uptake is enhanced by increased drying time which occurs during the moist times in the morning. Uptake is also greater in the light period than at night, thus making morning applications more desirable than evening sprays.

Table 5. Sources, rates, and final concentration of the micronutrient for a single corrective application of one or more micronutrients applied to the soil.*

Micronutrient Source	Weight of source/100 gal: oz	Weight of source/100 gal: grams	Final conc. (ppm)
iron sulfate--20% iron OR	4.0	113.4	62.0 Fe
iron chelate (EDTA)--12% iron	4.0	113.4	36.4 Fe
manganese sulfate--28% manganese	0.5	14.2	10.0 Mn
zinc sulfate--36% zinc	0.5	14.2	13.9 Zn
copper sulfate--25% copper	0.5	14.2	9.3 Cu
borax--11% boron OR	0.75	21.3	6.25 B
solubor--20% boron	0.43	12.2	
For soil-based media (>20% soil in media)			
sodium molybdate--38% molybdenum OR	0.027	0.77	0.77 Mo
ammonium molybdate--54% molybdenum	0.019	0.54	
For soilless media			
sodium molybdate--38% molybdenum OR	2.7	77	77 Mo
ammonium molybdate--54% molybdenum	1.9	54	

*Do not apply combinations without first testing on a small number of plants. Wash solution off foliage after application.

Table 6. Sources, rates, and final concentration of the micronutrient for single foliar sprays for correcting micronutrient deficiencies.*

Micronutrient Source	Weight of source/100 gal oz	grams	Final conc. (ppm)
iron sulfate	4.0	113.4	62 Fe
manganese sulfate OR	2	56.7	40 Mn
maneb fungicide	label rate	label rate	
zinc sulfate OR	2	56.7	56 Zn
zineb fungicide	label rate	label rate	
tri basic copper sulfate	4	113.4	159 Cu
sodium molybdate OR	2	56.7	57 Mo
ammonium molybdate	2	56.7	81 Mo

*Do not apply combinations without first testing on a small number of plants. Use the same spreader-sticker product and rate with the above foliar sprays as used with insecticide and fungicide sprays.

Literature Cited

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